DEEP CRUST AND MANTLE XENOLITHS, GRANATÍFERA TUFF, SW COLOMBIA - IMPLICATIONS FOR ANDEAN MAGMATISM

Marion B.I.Weber[1], John Tarney[1], Ray Kent[1] and Pamela D. Kempton[2]

[1] Department of Geology, University of Leicester, Leicester. LE2 1YB
[2] NERC Isotope Geoscience Laboratory, Keyworth, Nottingham NG12 5GG, UK

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INTRODUCTION

The Andean cordillera represents a major zone of continental crustal growth, but the details of the mechanisms remain controversial. One concern is the balance between *lateral accretion* through subduction-accretion processes, which tectonically intermixes continental detritus with scraped-off anomalous ocean floor, and *vertical accretion* through emplacement of mantle- or subducting slab-derived granitoids, or through basaltic underplating. A critical point is the nature of the deep crust beneath the Andean margin, which is commonly invoked as a component source in granitoid magmas, but there is little firm information available as to its major or trace element or isotopic character. Whereas xenolith suites brought up in volcanic breccia pipes provide such information on the composition of the deep crust and upper mantle, these are mostly available from the interior of cratons, or in back-arc regions (e.g. Pali-Aike, Patagonia) with only a few examples from *active continental margins* (e.g. Itinome-gata, Japan; Calbuco, S. Chile; Kodiak Island, Alaska). The Granatífera tuff-breccia, located east of Mercaderes, SW Colombia, provides a rich assemblage of mantle and deep crustal nodules essentially from beneath an active volcanic arc, and so provides a valuable window into the deep crust and crustal accretion processes. Is it possible to evaluate the contribution to Andean crustal growth?

PETROLOGY OF THE GRANATÍFERA XENOLITHS

The Granatífera tuff-breccia, located in SW Colombia (Figure 1), contains a rich assemblage of deep crust and mantle xenoliths. These include garnet peridotites, garnet pyroxene rocks, pyroxenites, garnet amphibolites and garnet granulites (cpx-gt-plg-qz). A proportion of the mantle xenoliths have deformation fabrics, the garnet peridotites in particular showing sheared mosaic porphyroclastic textures (Harte 1977), whereas the garnet pyroxenites show fine grained recrystallisation textures at grain boundaries. Thermobarometry on the deformed garnet peridotites provides estimates of pressures in the excess of 18 kb and temperatures over 860°C for the mantle rocks. Temperatures for the crustal rocks range from 890 to 1000°C for the garnet pyroxene rocks, 994 to 1048°C for the granulites, and 727 to 1036°C for the amphibolites, calculated at 10 kb. Pressures estimated for a garnet amphibolite are 12 to 13 kb. Other xenoliths (bombs) found in the Granatífera Tuff, are basaltic andesites and dacites, and amphibolitic pegmatites. Additionally there are low grade slates and schists representing upper crust compositions.

There is every reason to believe that this rich assemblage of rock types enclosed in an basltic andesitic to andesitic host (but with much comminuted crystalline debris) may be representative of the crust and

TRACE ELEMENT AND ISOTOPE GEOCHEMISTRY

Compositionally there is a complete range of rock types from ultramafic, through mafic and intermediate to silicic but, as with many other xenolith suites, there is a high proportion of basic rocks. The crucial issue is the petrogenetic relationships between these rocks.

Many of the andesitic and pegmatitic rocks have moderately high Al_2O_3 (> 15wt%), high Sr, very low Rb/Sr ratios, low Y, high K/Rb and low Nb, giving prominent *negative* Nb anomalies and *positive* Sr anomalies, as shown in Figure 2. The trace element characteristics are found in adakitic volcanics, generally linked with zones of ridge subduction (see Drummond and Defant, 1990), but are also found in much greater volume in Precambrian tonalite-trondhjemite-granodiorite ("TTG") suites (Martin 1994; Tarney & Jones 1994). There is a consensus that such trace element characteristics result from partial melting of a mafic source with hornblende and/or garnet in the residual assemblage. The conditions are most easily attained through partial melting of young, hot, subducting lithosphere (during ridge subduction), though are not necessarily unique to that environment. Additionally the majority of these xenoliths have low $^{87}Sr/^{86}Sr$ ratios (0.7035–0.7053). The isotopic characteristics imply that the mafic material must have a relatively short crustal residence time and not have suffered significant ridge hydrothermal activity or permeation by subduction fluids.

An additional petrogenetic factor is that the region to the west of the Mercaderes-Río Mayo area comprises a thick pile of mafic rocks, believed to be part of an accreted Cretaceous (ca. 88 Ma) oceanic plateau (Kerr *et al.* 1996). Although the upper altered parts of the plateau have clearly been imbricated, scraped-off and obducted, the deeper parts of this plateau may have "subcreted" beneath the continental margin, and suffered diverse dehydration-melting events to produced the extensive volcanism present at the surface, as well as that at depth, leaving behind a restite of amphibolitic to granulitic composition. Experimental studies and modelling of the melting of basaltic amphibolites has shown that restites include garnet amphibolites and granulites (cpx-gt±plg±hbl) (Rushmer 1993; Peacock *et al.* 1994; Sen and Dunn 1994). The more mafic crustal xenoliths of the Granatífera Tuff could represent these restitic materials; so the potential exists within the xenolith suite to evaluate and demonstrate these relationships.

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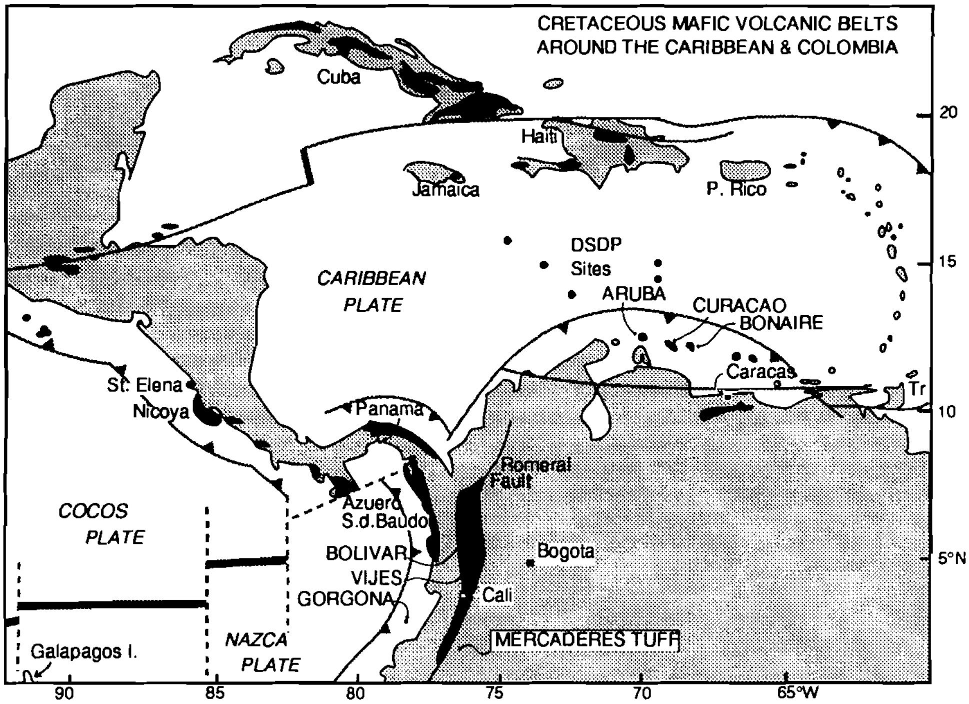

Fig. 1. Sketchmap showing location of Granatífera (Mercaderes) tuff, together with outcrops of accreted obducted mafic oceanic plateau sequences in Colombia and the Caribbean.

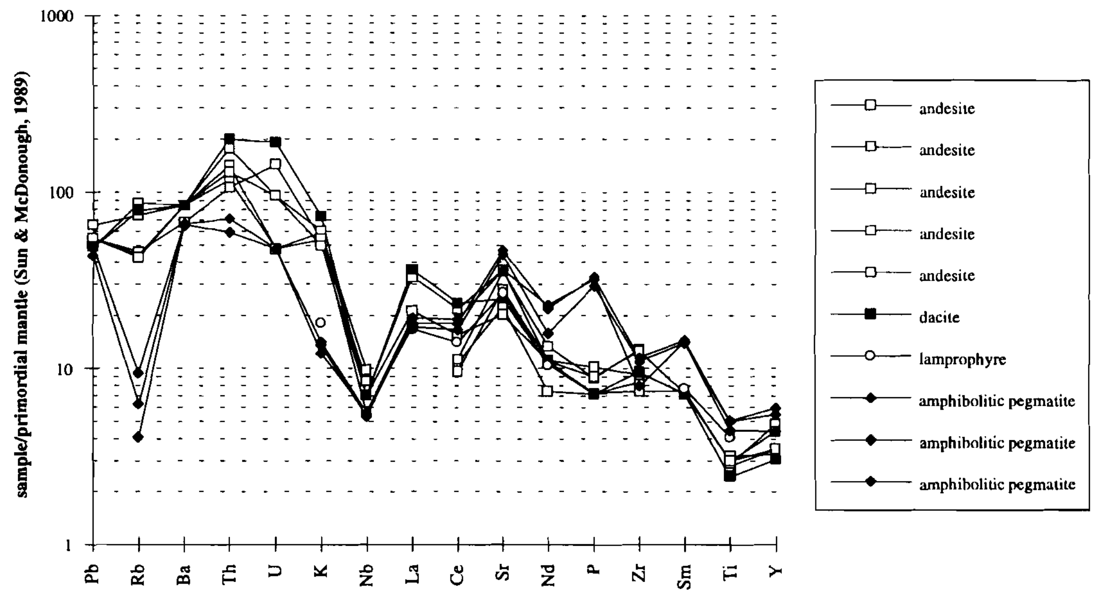

Fig. 2. Multi-element diagram (normalised to primordial mantle) of the volcanic and pegmatitic xenoliths from the Granatífera Tuff.